Dissolution of Dynamic Electronic Institutions, a first Approach: Relevant Factors and Causes

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***Abstract*—In the context of the Digital Business Ecosystems, small organizations cooperate between them in order to achieve common goals or offer new services for expanding their markets. There are different approaches for these cooperation models such as Virtual Enterprises, Virtual Organizations or Dynamic Electronic Institutions which in their life-cycle have in common a dissolution phase. However this phase has not been studied deeply in the current literature and it lacks formalization. In this paper a first approach for achieving and managing the dissolution phase is proposed, as well as a CBR process in order to support it in a Multi-Agent System.**

***Index Terms*—Dissolution, Electronic Institutions, Digital Business Ecosystems.**

I. Introduction

A Digital Business Ecosystem (DBE) is a digital self-organizing collaborative environment populated by *digital species* that interact, express independent behaviour and evolve following laws of market selection [1]. The DBE concept is aimed at the adoption and development of the Information and Communication Technologies (ICT) by the Small and Medium size Enterprises (SMEs) providing them cost-effective technology and innovative uses of ICT. Within the DBE, the SMEs can interact with each other and enable them to combine their services, allowing them to access to new market opportunities.

This combination of services between SMEs, searching to expand their services and looking for fulfilling common objectives, can be viewed as a creation of an organization or an institution. There are different approaches of organizations in a digital environment such as Virtual Enterprises [2] or Electronic Institutions [3] (and Dynamic Electronic Institutions later on [4]) that can be found on the current literature, and regarding to their life-cycles, we can find some common issues.

In the Virtual Enterprise approach from [2], there are 4 phases defined for its life cycle: Creation, Operation, Evolution and Dissolution. This last one can be reached by either the successful achievement of all its goals or by the decision of the involved partners to stop the operation of the Virtual Enterprise.

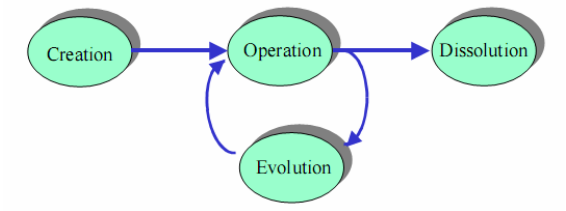

Fig.1 Life Cycle of a Virtual Enterprise, from [2]

The life cycle of the Dynamic Electronic Institutions is slightly different from the Virtual Enterprise's as it is composed by three phases, Formation, Foundation and Fulfilment (Fig 2, named as the 3F life-cycle [5]). The last phase, the Fulfilment is reached when the institution should be dissolved, and can occur when the institution is no longer needed or when it's no longer making profit.

It seems logical to consider a dissolution phase for any approach related to any kind of organization or institution, either from real or virtual life. In the approaches previously mentioned, there is a dissolution phase in their life cycle, which however is overlooked without getting into deeper research on it [6, 7].

But the reason that this particular phase is not studied deeply enough, is not because it's not an important phase; in economic terms, if an institution's dissolution is not properly managed, it can generate tremendous costs [8]. There are several issues to be managed, like the corporate intellectual property, the distribution of the benefits and of course the identification of the moment when an institution has to dissolve itself. The fact is that the current work in the state of the art focuses on the formation/creation phase.

The significance of the dissolution phase of any institution can be illustrated by taking the marriage institution as an example. In a marriage, if the dissolution phase (i.e. the divorce) is not properly managed and previously negotiated (e.g. the separation of marital property), the resulting costs can be huge. One real example, based on a Hollywood celebrity case, is the Michael Douglas' two marriages. On the divorce of his first marriage, with Diandra Luker he had to pay over than 50 million dollars and a house in Mallorca. For his following marriage, with Catherine Zeta-Jones, he

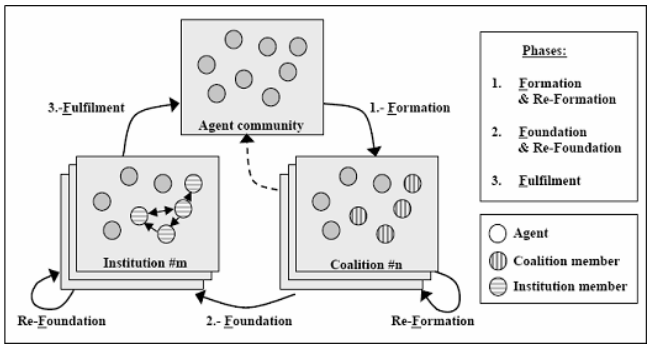

Fig.2 Life Cycle of a Dynamic Electronic Institution, from [5]

negotiated an amount to pay for every eventual divorce cause, previous to the contract signature. He learned from past experience, and then he stated the dissolution conditions and dissolution tasks before starting his new marriage.

The contribution of this paper is making a first approach to the dissolution phase of the Dynamic Electronic Institutions, identifying the activation of this phase and the tasks involved. In Section 2 we will refer to the relation between the DBE and Dynamic Electronic Institutions, and how norms can affect in them and in the dissolution phase. In section 3 we will take a real life normative environment to make it as our ground for the definition of the dissolution phase. In section 4 we will implement a simple example of agents making profits through dynamic institutions, and defining the dissolution moment within a CBR approach. Finally in section 5 the conclusions and the future work are presented.

II. Electronic Institutions and DBEs

Business Ecosystems represents an evolution of the conception of the networked economy. We can consider local economies as communities of interacting and evolving organizations just like as natural ecosystems, where the species compete, collaborate and evolve. The business organizations are considered as an organism that can collaborate with others in order to create more complex structures.

Joining together within networks, SMEs can offer complex services and create new market opportunities, combining and sharing knowledge, products, services and infrastructures (Fig. 3).

The DBE is the enabling technology for the Business Ecosystems. It is a digital pervasive environment populated by digital components which evolves and adapts to local conditions. It's not a piece of software or a business model, but a supporting business infrastructure offering and transporting services and information to empower the whole business network [9].

We can consider a DBE as an open agent system where the components (agents) are not known *a priori*, and represent the different organizations participating in it. Organizations forming alliances, joining efforts and combining services and products that allow them to fulfil objectives that

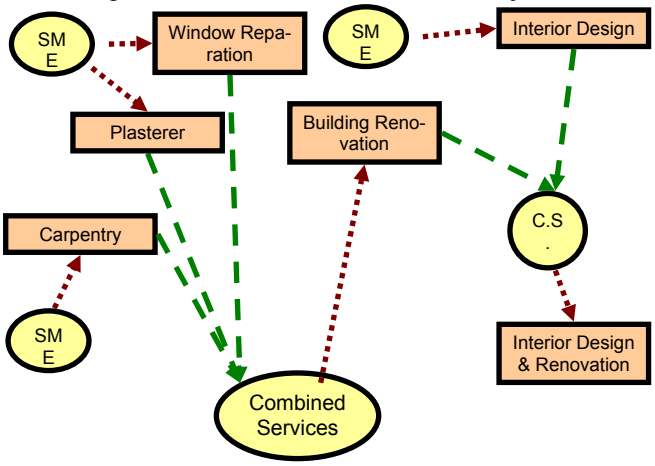

Fig.3 Example of a Business Ecosystem taken from [10]

in other way, couldn't be possible to reach in an electronic environment, have been studied before within different approaches.

Among the different types of networks, there is the Collaborative Network (CN) where different autonomous, heterogeneous entities form a network for achieving common goals. Virtual Enterprises (VE) are one of these CN, often described as a network of cooperating enterprises, that is, a group of pre-existing enterprises with some common goals that come together forming an interoperable network that acts as a single, temporary organization where the partners share skills and knowledge, have common goals and where the cooperation is peer to peer. Is a particular case of a Virtual Organization, which isn't limited to alliances between enterprises [11].

In the Virtual Enterprise literature, we can find references about its life-cycle, which is composed by a creation/configuration, operation and a dissolution phases (Fig. 1), and the need of supporting technological tools for each one of them, but for the case of the dissolution phase, there are not many references and even we can find the statement that is the less studied phase of its life-cycle [6].

Similar to the definition of the Virtual Organization, is the Electronic Institution. The institutions in the society define the way that we interact, represent the rules of the game, and establish laws, norms and rules for different situations or scenarios.

The use of organizational metaphors to model agent systems suggests structuring agent societies with roles and relationship between them. The first approach of an electronic institution can be found in [12], and the basic idea is a group of intelligent, autonomous and heterogeneous agents interacting between them under a set of norms in order to achieve individual and common goals. These norms, although add constrains to the system, reduces its complexity making the agent's behaviour more predictable.

There are different European research groups working on similar subjects, each one with its particular vision and perspective to the problem [3, 13, 14, 15 and 16], however in [5] some problems and limitations of the electronic institutions in open agent systems were observed (the lack of a short-term electronic institution vision, the need of an automatic design phase, how the entrance and exit of members affects the institution's norms and objectives and how it can dissolve its components once the institution has fulfilled its objectives), which led to the development of Dynamic Electronic Institutions (Fig. 2).

The current work related to the Dynamic Electronic Institutions (DEI) is mainly focused on the first phases of its life-cycle. Once again, there is not a deeper approach on the dissolution, and we add a new problem related to the fulfilment phase of the DEI in addition to the problem of how to dissolve its components:

If a DEI hasn't fulfilled all its objectives, should it be able to dissolve its components? When and why?

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III. First Approach of the Dissolution of a DEI

If something works in the social reality, it's not foolish to think that it could work in a system that is based on social relationships like the DEIs. To define the dissolution phase of a DEI in a business environment as the DBEs, a good place to look is the Commercial Law. In particular, we will look on the extinction of the Limited Companies.

In the aspect of the dissolution, commercial law is very similar within the different countries in the European Union[1], and they identify two phases before the extinction of a society: The dissolution process and then the liquidation process [17].

The dissolution process identifies when a company can be dissolved and then proceed to the liquidation process. There are several causes identified in the law and we can separate them in two groups, the ones that automatically drive to the liquidation process (we will call them *decisive causes*), and the ones that allow to take measures to avoid the liquidation process and require an agreement between the different members of the company's general board (we will call these causes *conditioning causes*) in which is the fulfilment of all the objectives among other causes.

After the dissolution process has finished, the liquidation process starts. Here the roles of the company change and some of the members (usually the administrators) take the role of *liquidators*. First, the company has to close their pendent commitments, and then the liquidators basically have to take inventory and elaborate a wealth balance of the company which has to be approved by the company's general board. After that, a liquidation share is paid to each member of the company, based on the participation of each one of them (unless in their statutes is specified something else).

The companies have, under the law, a local set of rules and norms: their statutes. These statutes can determine dissolution causes added to the ones specified by the law, and can change some values in the liquidation process like the distribution of the earnings (or debts).

The Electronic Institutions provide a normative system of reference under which agents reach cooperation agreements. This cooperation agreement implies that the agents are subject to a set of norms that regulate and support interactions taking place within the Electronic Institution [18].

In the DEI context, we can consider this normative environment as analogous to the real world company's statutes, which are included in the institutional contract the partners agreed during the acceptance step of the DEI [5].

Also, the identification of the different dissolution causes depends on the performance of the institution. Some causes depend on the activity (or lack of) of the institution, so there should be a monitoring mechanism supporting the institution. For the DEI's performance monitoring, contextualized norms defined for each agent commitment inside the institution is suggested in [19]. This monitoring allows maintaining internal trust levels or the creation of performance cases for future references that will support the dissolution phase.

[1] We will use the Spanish commercial law as reference

Inspired by the normative framework proposed in [18], we identify three normative levels (Fig. 4).

Institutional norms refers to the norms inside the whole environment where institutions are formed and dissolved, is the law which regulates the behaviour of every agent, contains the common norms for the whole system and default templates for cooperation agreements. These norms are contained in the DBE.

Constitutional norms are created when a cooperation agreement is reached before the creation of the DEI. Can define additional dissolution causes, and describes the constitution of the DEI, when the DEI is modified (like in a re-foundation situation, the entrance of a new partner, the modification of its objectives), these norms are changed too. We can relate it to the companies' statutes.

Operational norms are created for every task inside the institution. Every commitment for any action should have a related operational norm; this will help for monitoring the performance of the DEI.

These norms will help for supporting the dissolution phase where, based on the contract law, we can identify two processes: The activation and the liquidation.

The activation process is when the DEI identifies a situation that could be a dissolution cause. Then, depending on the activation cause (if it is decisive or if it is conditioning), the DEI has to decide if it wants to proceed to the liquidation or if it decides to modify itself in order to continue operating.

During the liquidation process we identify 5 liquidation tasks, inspired by the commercial law's liquidation tasks:

1. Proceed: The DEI has to decide if it wants to go on to the liquidation process or instead, modify its structure within a re-foundation process to avoid its extinction.
2. Calculate: Make an overall balance of the DEI's wealth, identify the pending tasks and their priority.
3. Allocation and Execution: If there are mandatory tasks identified, assign and execute them.
4. Collect: Retrieve pending transactions with external organizations in case that the Institution has interacted with others. This will allow making the final balance of the institution.

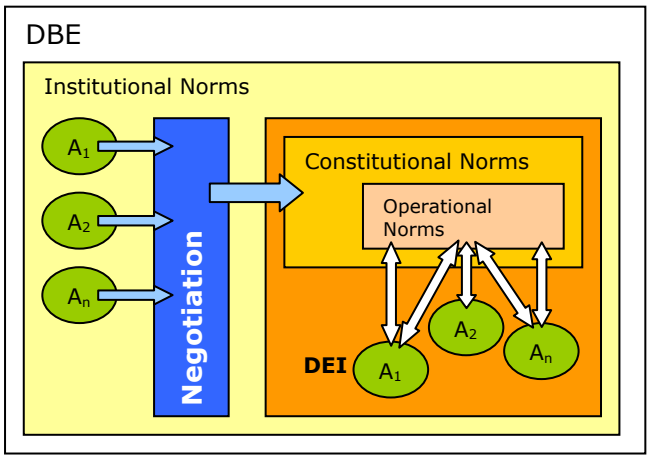

Fig.4 Normative levels in the DBE and the DEI

5. Share out: The distribution of the earnings or debts, based on the partners' contribution in the company, or by the contract specification [5]. Before the distribution, there must be an agreement between the partners about how the earnings will be distributed. If there is no agreement, a new balance should be made.

The formalization of the DEIs (from [5]) suggests a previous case knowledge approach (e.g. Case Based reasoning, CBR) for the automation of the formation of new DEIs [7], this min that for supporting the CBR, there must be a knowledge base about previous institutions, which is created when each DEI is dissolved. So, finally after the liquidation process has finished, a common knowledge base should be updated within a report of the institution elements.

We suggest that the knowledge base could be also used for supporting the dissolution process to automate cause's identification like the potential inability for fulfilling the objectives in the actual conditions. For this purpose, the report should include several evaluation reports related to the performance of the institution in different times [20] during the operation of the DEI. This will help to identify future cases and to predict measures to take or if the institution shouldn't continue operating. This report, in its simplest form, should include the time that have been made, the expected level of fulfilment of the tasks at that time, and the actual real level of fulfilment of these.

IV. An Automated Dissolution Approach

For this work, we implemented a digital environment where agents in a space forms consecutive coalitions (as we wanted to focus only in the dissolution, the coalition formation process is done automatically having no intelligence there) with a fixed operation time (in time steps).

The mechanism is simple. Agents move and interact asynchronously through a grid space (which represents the ecosystem), and when they find another agent in their neighbourhood (nearer than two cells), they send a message proposing the creation of a coalition. In the next time step, proposed agents answer if they accept or not. Every agent in the system offer a single (not unique) service, the advantage of forming a coalition is that two agents together can offer their own service plus their combination, expanding their markets.

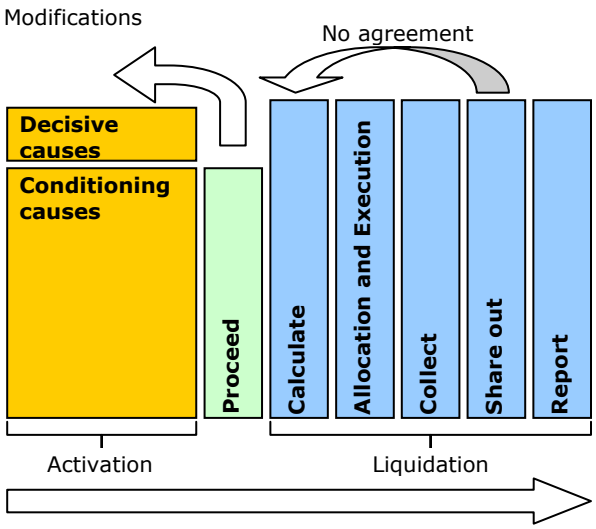

Fig.5 Dissolution process

The idea is to demonstrate the utility of supporting tools to automate the dissolution causes identification, and the need of a transitional step between the activation and the liquidation for deciding if to proceed or not. We will use a previous case knowledge approach to identify when the agents expectations probably will not be fulfilled.

The dissolution causes we are going to focus in are the *deadline fulfilment* (when the expected lifespan is reached) and the *inability* (that identifies when is not convenient to continue operating as the earning expectations cannot be fulfilled).

For the simulation, we made the following hypotheses related to the agents:

1. Each agent offers a single service.
2. Agents who coalesce are more probable to get benefits. To the extreme that, for this case, single agents get no benefits (1 bis).
3. When agents coalesce, there are three options related to the coalition lifespan: a) set a fixed lifespan, b) do not fix a lifespan and c) set an initial lifespan which can be changed.
4. In the specific negotiation scenario, at least two agents coalesce; a tender and one or more tenderees.

As for the calculated benefits and coalition services, we assume that:

1. Two or more agents offering the same service can't be part of the same coalition.
2. The benefits are calculated based on the services a coalition offer and the demand they have.
3. The coalitions will offer the individual services of each member agent, as well the combination of these services. For example, if a coalition is composed by two agents, which respectively offer the services A and B, the coalition will offer the services A, B and A+B (Fig. 6)
4. Every service has the same base demand, as well the combined services.
5. The demand of a service depends of the competition that this service offering has (how many coalitions offer the same service). For example, if a coalition offers the services A, B and A+B, and another active coalition offers the services A, C and A+C, there will be two competitors for the service A.

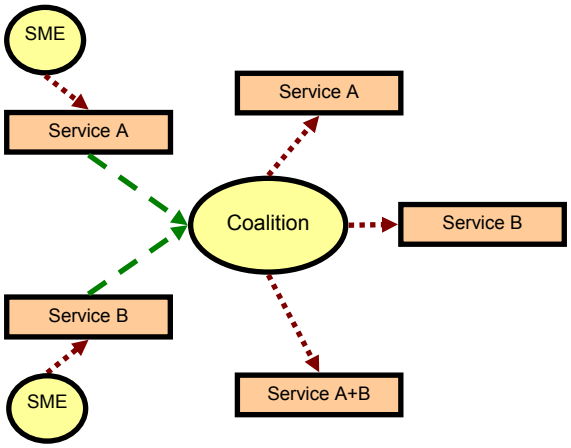

Fig.6 Addition of services in the simulation

Earnings for each time step are calculated by the following equation (1):

$$E = \sum_{i} (B / C_i + N) \qquad (1)$$

Where:

E is the total earning of the coalition.

B is the base earning for each service i.

C is the number of coalitions that offer the same service i (including the coalition that the earnings are being calculated).

N is a random number from a normal distribution with average 0 and variance (B/2).

This implies that a coalition with greater diversity in the services it offers will have lesser competition.

We mentioned before that for supporting the dissolution, we will use a previous cases knowledge method. In our first approach we will use Case Based Reasoning (CBR, which from now on we will refer as *the algorithm*) to identify cases when it's better to dissolve the coalition as the earning expectations cannot be fulfilled, or when the coalition's lifespan is about to reach its end, identify if it's better to extend it instead of proceeding to the liquidation.

During the operation of the coalition, it will create evaluation cases to retain them in the knowledge base. The evaluation cases, for the sake of simplicity, will contain only the earned money from the last evaluation, the diversity of the offered services and the time steps passed from the last evaluation. There will be three evaluation moments; one at the beginning, other at the middle and a last one just before the coalition's deadline. If the deadline is extended, there will be added new evaluation cases.

The algorithm, in his retrieving step, will identify pairs of consecutive evaluations similar to the current and past evaluations. Once a similar case is found, the algorithm will try to predict the following state based on the past cases and evaluate, reusing the past similar cases, which is the best action to do for the coalition: if is better to continue operating extending its lifespan or dissolve.

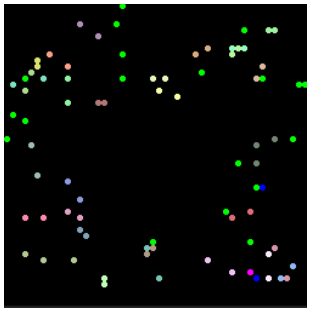

Fig.7 Agents moving in the space in the simulation

The similitude for the CBR is calculated by (2):

$$Sim = (Div_k * w_1 + Ear_k * w_2) + (Div_{k-1} * w_1 + Ear_{k-1} * w_2) \qquad (2)$$

Where:

Div is the diversity similitude at a time k and a time k-1.

Ear is the earnings similitude per time step at a time k and a time k-1.

w_n are the respective weights for the similitude values.

In the knowledge base there must be an evaluation at a time k+1 in order to estimate the earnings.

The minimum and maximum earning expectations (exp_{min} and exp_{max}) for each agent in the coalition are (3):

$$\exp_{\min} = B/5$$
$$\exp_{\max} = B/2 \qquad (3)$$

B is the base earning for a service, from equation (1).

To identify positive cases from the negative ones, the algorithm will compare the earning expectations with the benefits founded in the similar cases from the knowledge base, reusing them.

The simulation environment has been developed in RePast[2], and the tests were done in a grid of 50x50 cells, with 500 different agents that can offer one of the 10 different services. The base earning for each service was fixed in 1, and the default duration time of a coalition was 15 time steps. We tested it during 10.000 time steps in three different scenarios:

Experiment 1: When the coalitions start with a defined lifespan, which it can be extended or reduced, supported by the algorithm.

Experiment 2: When the coalitions have an unlimited lifespan, so new coalitions can never be dissolved (this because as agents only get earnings when are in coalition -from hypothesis 2bis-, to compare this experiment with the others that have agents without coalitions wandering in the grid more often).

Experiment 3: When the coalitions have a fixed lifespan which cannot be modified.

After ten runs of 10.000 steps for each experiment, the results on the average earning at each step can be seen on Fig. 8. After the step 8.600 the earnings per step seem to stabilize, so for the results we will consider for the average benefits are from the step 8.600 onward.

The average total earnings are:

	Average	Std Deviation
Experiment 1	1.530,04	12,69

[2] http://repast.sourceforge.net

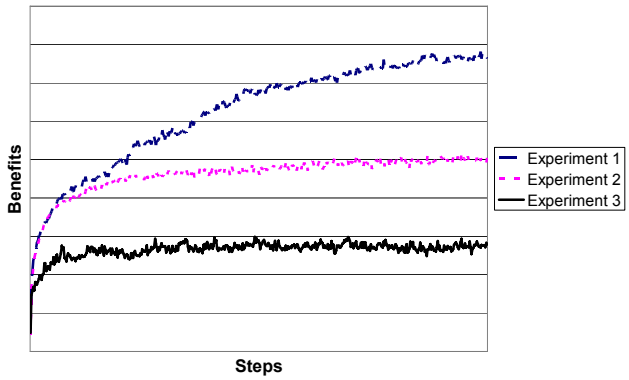

Fig.8 Average earning, 3 experiments, 10 runs, 10.000 steps each

Experiment 2	997,21	13,35
Experiment 3	543,77	16,26

As we can observe, there is a significant improvement when the algorithm supports the identification of the dissolution time of the coalition (experiment 1). In the experiment 2 there aren't many agents out of a coalition, and in consequence not earning money, but this doesn't guarantee that they are in the best possible coalition, or maybe they are better searching for new ones without making benefits instead being part of a bad performing one.

V. Conclusions and Future Work

We made a first approach on the dissolution phase of the DEIs that can be extended to other types of collaborative networks. In this approach we identified two processes: the activation of the dissolution and the liquidation of the institution.

The activation is determined by different causes, but this activation doesn't mean necessarily that the institution must continue to the liquidation. Depending on the activation cause, the institution can modify itself (*evolve* in the Virtual Enterprise approach from [2] or enter in a *re-foundation* in the DEI approach from [5]) for continuing its operations and exiting from the dissolution phase.

In our first approach we presented the *deadline fulfilment* and the *inability* dissolution causes, supported by a CBR for its automation, reusing the knowledge base used for the institution formation. These causes depend on the norms adopted by the institution previous its formation, as in there are specified the expected lifespan of the institution and the expected earnings.

The negotiation process in the current model is made automatically, but is expected to be added more complexity into it, like dissolution issues among the negotiation elements. This is expected to be implemented in the context of the project ONE [21].

The next step is to focus on the liquidation process, how it can be driven, how the norms affect it, what has to be negotiated and what has to be considered for this task during the negotiation. Also a full formalization of the dissolution phase and its norms is expected.

Business situations are complex and aren't easy to simulate, that's why these results are considered as preliminary. At the time, we oversimplified the model for focusing our study only in the dissolution activation causes mentioned before.

At this time this topic hasn't been studied in deep, and the future related work offers a wide open field of research that needs to be explored for the study of the Electronic Institutions.

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